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Sand Ships of Mars

By: Jeff Beish

Association of Lunar and Planetary Observers (A.L.P.O.)

INTRODUCTION

It was Ray Bradbury who wrote of the *Sand Ships of Mars* in his science fiction novel, The Martian Chronicles (*Bradbury*, 1946). One can imagine the fictional inhabitants of Mars trekking across its deserts in their floating machines stirring up huge dust devils. This great science fiction story set the stage for this author's interest in Mars and who now writes about similar accounts of the real dusty whirlwinds of Mars.

The dark surface markings were once thought by some astronomers to be great lakes, oceans, or vegetation, but space probes in the 1970's revealed the markings to be vast expanses of rock and dust. No wonder science fiction writers were so eager to conceive of life on Mars.

COLORS OF MARS

What color is Mars through a telescope? This question has been asked by astronomers for at least three centuries and is a subject of debate even today. Observers even report certain dark features on Mars grow darker and even change color during seasonal transitions. This has led to some startling conclusions, some of which has brought the wrath of the scientific community down on a few very prominent astronomers.

Confusion over the colors of Mars is nothing new. Reports of green or even blue features on Mars are common from ground-based observers. In the early 20th century, some astronomers saw the apparent greening of Martian maria, during spring and early summer, as proof that vegetation it was the cause. We have since found that the human eye is subject to a variety of illusionary perceptions, one being the inability for us to correctly identify colors in low light conditions.

We may have a good idea of what the average human response to a particular color might be on Mars; however, observers often describe the planet's colors completely different even while using the same telescope.

A layer of volcanic ash and rock covers the surface of Mars, at least in the smooth areas where the United States landed two spacecraft during the 1970's. Using the robotics arms on each of the two Viking Landers the nearby surface was sampled and the results suggested a surface of ash-like material be saturated by water vapor.

When similar materials on Earth are saturated to water vapor it tends to darken and/or change color hues. Also, during the colder Martian seasons its surface has been observed to covered with frost or snow like condensates that tend to brighten some areas and make adjacent dark areas appear darker that they really are.

Hoarfrost in Earth's surface tends to clump ash-like and sandy materials into mounds or irregular piles, which will appear darker, especially when, accompanied with long shadows. However, when viewed from certain incident angles, these same piles may appear brighter.

Using the proper color filters one can determine colors of Martian features, usually red; however, we have found that certain atmospheric clouds display blue to blue white color at times [*Beish et al,* 1988]. Even without filters there are a few clouds that appear bluish, such as the "Capen Blue Syrtis Cloud." This cloud shows up often during Martian northern spring (southern autumn) and will appear blue-white visually. In photographs taken with color film and tri-color CCD images this cloud is a vivid blue. To prove this observers can use a yellow filter on Mars to see this particular blue cloud turn greenish in the filtered image. It is usually brighter in blue color, that is while observing Mars with a blue filter, and darker in red light.

Dust clouds often appear bright yellow in the telescope without observing with filters. They are usually brightest in red light, but can be also bright in yellow light. Dust clouds will be blurry or hazy in yellow light. A blue filter will not brighten the dust cloud and often will make the dust cloud appear to vanish. However, we have found that white-yellowish clouds can accompany dust clouds so the observer should watch for these phenomena. Look for a dusty polar cap following any dust clouds they show up in red and green light.

Since Mars is red in color it will be brightest in red or orange filters.

While observing Mars using a deep blue or violet filter the surface features will most often disappear and only a dull bluish haze will been seen. Occasionally surface features will appear dark in deep blue light, a phenomenon not well understood.

Some Hints on observing Mars: **Observed both at night and in twilight hours. Difficult to observe due to bright surface. Mars is similar to Earth because the surface and it's atmosphere can been seen.**

Table 1. Eastman Kodak Wratten Filters used by A.L.P.O. observers. Characteristics for Mars Observations.

Wratten Filter	Remarks
Yellow (W12, W15)	Brighten desert regions, darkens bluish and brownish features.
Orange (W21, W23A)	Increases contrast between light and dark features, penetrates hazes and most clouds, and limited detection of dust clouds
Red (W25, W29)	Gives maximum contrast of surface features
Green (W57)	Darkens red and blue features, enhances frost patches, surface fogs, and polar projections.
Blue-Green (W64)	Helps detect ice fogs and polar hazes.
Blue (W80A,W38, W38A)	Shows atmospheric clouds, discrete white clouds, and limb hazes, equatorial cloud bands, polar cloud hoods, and darkens reddish features.
Deep Blue (W46, W47)	Same as Blue above plus W47 is the standard filter for detection and evaluation of blue or violet clearing.
Magenta (W30, W32)	Enhances red and blue features and darkens green ones. Improves polar region features, some Martian clouds, and surface features.

MARTIAN DUST CLOUDS

Each apparition experienced Mars observers slowly grow familiar with the dark and light features on Mars with a regular systematic observing program. Those who regularly observe Mars during the early months of an apparition will develop the ability to recognize these features even without consulting Mars charts. More importantly, an observer who notices a sudden disappearance of a familiar feature may just be seeing

the beginnings of dust storm conditions. Among one of the most exciting moments to a Mars observer is to catch a dust storm on the move. It is rare indeed when one can watch one of these great red clouds slowly move over the Martian landscape covering over features that were dark and well defined just hours before. Windstorms sometimes move the dust, resulting in both seasonal and long-term changes.

Although immense global dust storms are firmly entrenched in Martian lore, they may be rare. Lowell Observatory's Leonard Martin has written that there have been only five well-documented "planet-encircling" Martian storms. These storms occurred in 1956, 1971, 1973, and two storms in 1977 (these were discovered by Viking Spacecraft) [*Martin*, 1984]. However, smaller dust storms or dust clouds are observed on Mars. These dust clouds are very difficult to identify in their beginning stages and, in some cases, go undetected even after they have fully developed.

A careful diagnosis of observational records of Mars from the Perihelic apparitions since 1907 show evidence that Martian dust storms have evolved in preferred southern locations near the latitude of maximum insolation. Maximum insolation occurs during Martian southern summer, which corresponds to the terrestrial months of August, September, and October of Perihelic apparitions [*Capen* and *Martin*, 1971] and [*Capen* and *Martin*, 1972]. Recent studies of Martian dust storms reveal three periods in the Martian year when dust clouds and/or storms are most likely to occur. These periods correspond to 105° (northern summer), 255° Ls (southern spring), and 315° Ls (southern summer). [*Beish* and *Parker*, 1990].

Since 1971, the year of the "Great Dust Storm of Mars," the ALPO Mars Recorders have suspected that these disturbances came in pairs. We have seen that in 1971 a major dust storm occurred on 213° Ls, followed by a "planet encircling" dust storm on 260° Ls. Again, in 1973 a major storm began on 244° Ls and was followed by a "planet encircling" storm on 300° Ls and [*Martin*, 1974]. The Viking Lander recorded two "planet encircling" storms on 204° and 268° [*Tillman*, 1988].

Although the two dust storms of 1988 did not reach the "planet encircling" stage, similar patterns emerged; during 206° Ls a major

storm occurred, followed by another major storm on 313° Ls [*Beish* and *Parker*, 1988] and [*Beish* and *Parker*, 1989].

Perhaps the statistical significance of the three periods above appear to mislead us when attempting to predict when these disturbances should occur. However, one should be especially alert when observing Mars during these times. The next apparition of Mars will again give us a chance to observe these sensitive periods, so be watchful, alas, a major dust storm may be lurking just around the corner!

While working with the late Leonard Martin (Planetary Research Center, Lowell Observatory, Flagstaff, Arizona) and Richard W. Zurek (JPL) on problems of correctly

Identifying and classifying Martian dust clouds or storms, new guidelines have been established by the A.L.P.O. Mars Recorders for interpreting Martian dust clouds and dust storms, they are classified as:

Table II. Guidelines for interpreting Martian dust clouds and dust storms.

Type of Observation	1. White cloud or bright areas mistaken for dust cloud
	2. Visual observation(s) of dust clouds in a dust storm.
	3. Instrumental observation(s) of dust cloud/storm (Includes photographic, polarimetric, spacecraft data, or other data obtained by instrumental means).
Martian dust clouds	1. Obscuration (obstruction)--Not sure if surface or atmospheric.
	2. Dust Haze--Partial obscuration with displacement.
	3. Bright dust cloud--Bright obscuration with displacements.
	4. Limb projection/terminator protrusion by dust cloud.
Martian dust	1. Local--Dust storm with major axis not to exceed 2000 km

storms	(1,243 miles or less than 34 degrees).
	2. Regional--Dust storm with major axis that exceeds 2000 km (1,243 miles or less than 34 degrees) but not encircling either or both hemispheres.
	3. Planet Encircling--Dust storm with major axis that completely encircles either one or both hemispheres of Mars.

As a general rule, a Martian dust cloud will qualify if they 1) are bright in red light, 2) show movement with obscuration of previously well-defined albedo features, and 3) may cast a shadow.

Much has been written about the characteristics of these dust clouds and how to detect them. These dust clouds are very difficult to identify in their beginning stages and, in some cases, go undetected even after they have fully developed. On the other hand, some observers have confused bright Martian desert regions or bright fog areas with dust clouds. The bright orographic clouds (clouds over mountains) in Tharsis region of Mars may appear as dust clouds. The yellow-white appearance of some clouds most likely indicates the presence of dust particles; observers should not classify all bright clouds that appear to be yellowish as "dust clouds."

While no two dust clouds are alike they nevertheless exhibit similar characteristics. Dust clouds are frequently confused with bright white areas, frosts, or localized fogs, and some dense white clouds. In addition, after identification is made, it becomes difficult to distinguish active dust clouds from fresh surface dust deposits. Such misinterpretation can make time studies difficult.

The one thing that must be avoided in reporting dust storms is a false alarm. Our mentors in the professional community take a dim view of wasting considerable time and money on spurious information. Thus, after consultation with professionals, we have revised our criteria for Martian dust activity.

The astute reader will note that nowhere in this article will the adjective

"yellow" been applied to dust clouds. In the past we have referred to dust storms as "yellow clouds" and "yellow dust storms." We feel that this is misleading. First, it is virtually impossible to see or even photograph accurate colors on Mars without employing very specialized techniques. Traditionally, observers have employed yellow filters to better reveal dust clouds. The problem is that nearly EVERY light feature on Mars is bright through a yellow filter!

Numerous reports of yellowish hazes have appeared in the literature and in the A.L.P.O. International Mars Patrol archives. Mars observers frequently report "albedo features" lacking in contrast, the planet is "washed out," or Mars' atmosphere is "dusty." These terms have been employed in the past by the Mars observers. While such descriptions may have merit, generalized yellow hazes and temporary losses in surface contrast is usually omitted in our reports. Photographic evidence for these phenomena is also weak, since the proper sensitometric calibration is usually lacking.

Confusion over the colors of Mars is nothing new. When the bright planet Mars is observed against a nighttime sky, the planet's predominantly orange colored surface becomes highly saturated to the eye. The darker albedo features, when observed against this saturated background are perceived as complementary hues. This effect is known as "*simultaneous contrast*" [*Hartmann*, 1989].

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